Conclusions and Summary Report on an Environmental Life Cycle Assessment of Utility Poles

ISO 14044 Compliant

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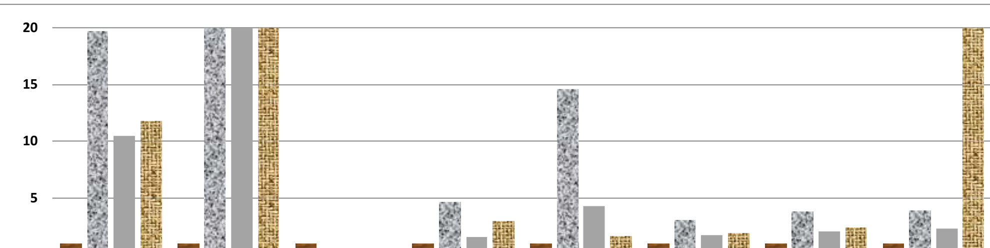
Conclusions and Summary Report

1. Conclusions & Executive Summary

The Treated Wood Council has completed a quantitative evaluation of the environmental impacts associated with the national production, use, and disposition of pentachlorophenol-treated wood, concrete, galvanized steel, and fiber-reinforced composite utility poles using life cycle assessment (LCA) methodologies and following ISO 14044 standards. The results for treated wood poles are significant.

- **Less Energy & Resource Use**: Treated wood utility poles require less total energy, less fossil fuel, and less water than concrete, galvanized steel, and fiber-reinforced composite utility poles.
- **Lower Environmental Impacts**: Treated wood utility poles have lower environmental impacts than concrete, steel, and fiber-reinforced composite utility poles in five of the six impact indicator categories assessed: anthropogenic greenhouse gas, total greenhouse gas, acid rain, ecotoxicity, and eutrophication-causing emissions.
- **Decreases Greenhouse Gas Levels**: Treated wood utility poles lower greenhouse gas levels in the atmosphere while concrete, galvanized steel, and fiber-reinforced composite utility poles increase greenhouse gas levels in the atmosphere.
- **Offsets Fossil Fuel Use**: Improved reuse of pentachlorophenol-treated utility poles for energy recovery will further reduce greenhouse gas levels in the atmosphere, while offsetting the use of fossil fuel energy.

Figure 1 Impact indicator comparison (normalized to pentachlorophenol-treated utility pole = 1.0)



	Greenhouse Gas	Acid Rain	Smog	Eutrophication	Ecotoxicity	Total Energy Input	Fossil Fuel Use	Water Use
Pentachlorophenol-treated	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Concrete	20	77	0.40	4.7	15	3.0	3.8	3.9
Galvanized steel	11	54	0.18	1.5	4.3	1.7	2.0	2.3
Fiber-reinforced composite	12	38	0.15	3.0	1.7	1.9	2.4	27

Notes: Some acid rain and water use values exceed the presented vertical scale of this graphic. Total greenhouse gas is not shown because of negative vulues for pentachlorophenol-treated poles.

Impact indicator values for the cradle-to-grave life cycle of pentachlorophenol-treated utility poles were normalized to one (1.0), with concrete, galvanized steel, and fiber-reinforced composite utility pole impact indicator values being a multiple of one (if larger) or a fraction of one (if smaller). The normalized results are provided in Figure 1.

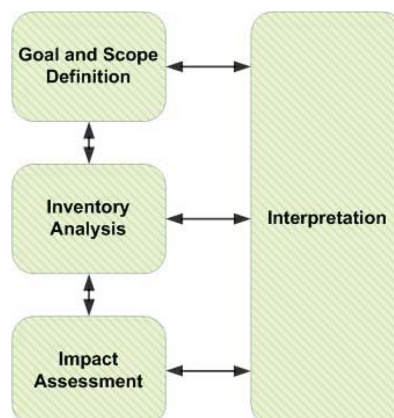
The carbon embodied in wood products, such as utility poles, is removed from the atmosphere during growth, stored for decades while the product is in use, and can be used for beneficial energy recovery at disposition. This temporary storage of carbon in the wood product reduces atmospheric levels of CO_2 because the service life of the pole exceeds the time required for tree growth.

2. Goal and Scope

The goal of this study is to provide a comprehensive, scientifically-based, fair, and accurate understanding of environmental burdens associated with the manufacture, use, and disposition of utility poles using LCA methodologies. The scope of this study includes:

- A life cycle inventory of four utility pole types: pentachlorophenol-treated wood, concrete, galvanized steel, and fiber-reinforced composite. Pentachlorophenol was chosen as a representative preservative for assessment of treated wood utility poles.
- Calculation and comparison of life cycle impact assessment indicators including: anthropogenic greenhouse gas, total greenhouse gas, acid rain, smog, ecotoxicity, and waterborne eutrophication impacts potentially resulting from life cycle air emissions.
- Calculation of energy, fossil fuel, and water use.

3. Quality criteria



This LCA study was done in accordance with the principles and guidance provided by the International Organization for Standardization (ISO) in standards ISO/DIS 14040 and ISO/DIS 14044. The LCA procedures and findings were evaluated by a panel of external reviewers in accordance with Section 6 of ISO 14044. The external reviewers confirmed that the LCA followed the ISO standards and that the comparative assertions were done using equivalent functional units and equivalent methodological considerations.

4. Manufacturer Information

This LCA addresses products from multiple utility pole manufacturers.

- The LCA for pentachlorophenol-treated wood utility poles includes weighted averages of survey responses representing 38% of the total U.S. pentachlorophenol-treated utility pole market.

- The LCAs for concrete, galvanized steel, and fiber-reinforced composite utility poles represent general product categories, manufactured with different designs and material contents. These LCAs provides a basis for general comparison of products.

5. Product Description and Functional Unit

For collection of LCA inventory inputs and outputs and comparative purposes, a 45 foot pole meeting National Electrical Safety Code Grade C design standards was chosen as a baseline product.

Scope: Cradle-to-grave

Functional unit: one 45 foot utility pole capable of 2,400 pounds of horizontal load applied two feet from the pole's tip

Service life: 60 years

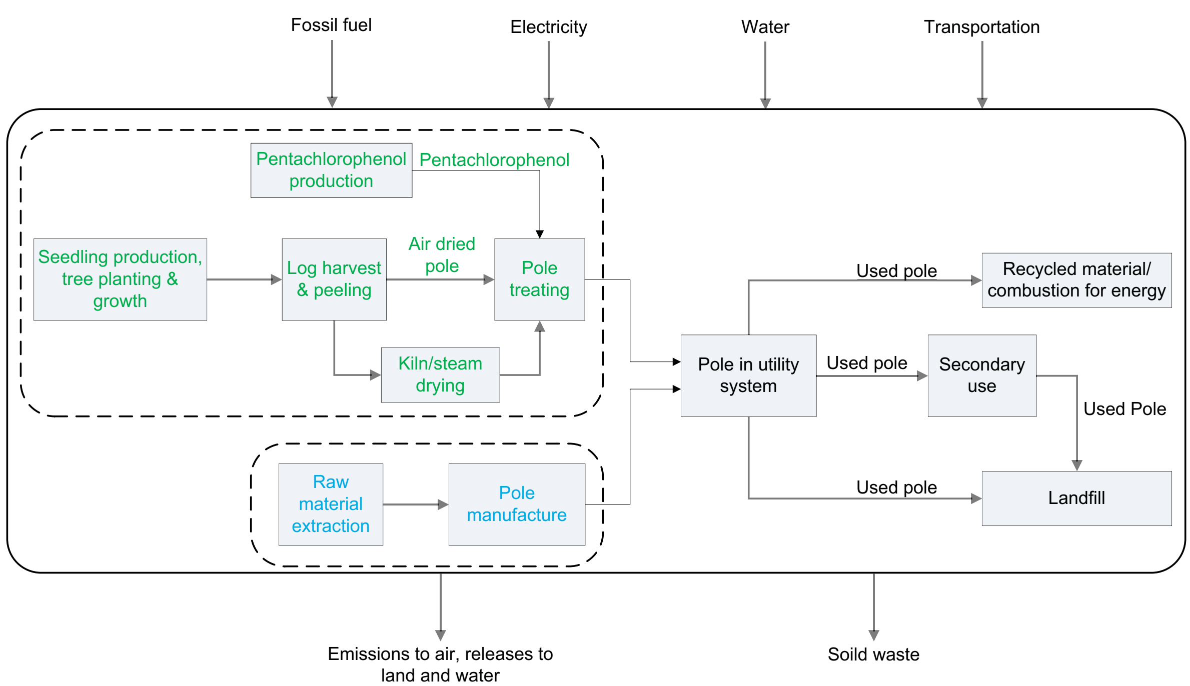
System boundary: from the extraction of the raw materials through processing, transport, primary service life, reuse, and recycling or disposal of the product.

Geographic boundary: U.S.

6. Life Cycle Inventory

The inventory analysis phase of the LCA involves the collection and analysis of data for the cradle-to-grave life cycle of the utility pole. For each stage of the product life cycle, inputs of energy and raw materials, outputs of products, co-products, and waste, and environmental releases to air, water, and soil are determined.

Figure 2 System boundary and process flows for utility poles (cradle to gate processes for pentachlorophenol-treated are shown in green and non-wood products are shown in blue)



The system boundaries include all the production steps from extraction of raw materials from the earth (cradle) through to final disposition after its service life (grave). Figure 2 illustrates the system boundaries and process flow for both wood and non-wood utility poles assessed in this study.

The length of time a utility pole remains in a utility line is dependent upon a number of factors. Often, poles are removed from service before the end of their useful service life, such as for road widening. Assumptions used in this LCA for disposition of utility poles after service life include:

- Pentachlorophenol-treated poles are recycled for secondary use, burned as fuel, or disposed in a solid waste landfill
- Concrete poles are disposed in a solid waste landfill
- Steel poles are recycled
- Fiber-reinforced composite poles are burned for energy recovery or disposed in solid waste landfills

7. Environmental Performance

The assessment phase of the LCA uses the inventory results to calculate total energy use, impact indicators of interest, and resource use. The asssessement classifies inputs and outputs in categories for calculation of energy use, environmental indicators, and resource use. For environmental indicators, USEPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) is used to assess anthropogenic and total greenhouse gas, acid rain, smog potential, ecotoxicity, and eutrophication impacts potentially resutling from air emissions. The categorized energy use, resource use, and impact indicators provide general, but quantifiable, indications of environmental performance. The results of this impact assessment are used for comparison of all utility pole products as shown in Table 1.

Table 1 Environmental performance (per pole)

Impact category	Units	Pentachlorophenol-treated pole	Concrete pole	Galvanized steel pole	Fiber-reinforced composite pole
Energy use					
Energy input (technosphere)	MMBTU	4.0	6.5	2.9	0.19
Energy input (nature)	MMBTU	1.5	10	6.5	11
Biomass energy	MMBTU	1.5	0.094	0.11	-0.012
Environmental indicators					
Anthropogenic greenhouse gas	lb-CO_2-eq	162	3,190	1,699	1,911
Total greenhouse gas	lb-CO_2-eq	-789	3,213	1,725	1,908
Acid rain air emissions	lb-H+ mole-eq	11	886	622	436
Smog potential	g NOx / m	13	5.0	2.3	1.9
Ecotoxicity air emissions	lb-2,4-D-eq	1.3	19	5.5	2.1
Eutrophication air emissions	lb-N-eq	0.068	0.32	0.10	0.20
Resource use					
Fossil fuel use	MMBTU	4.1	16	8.4	10
Water use	gal	46	180	106	1,248

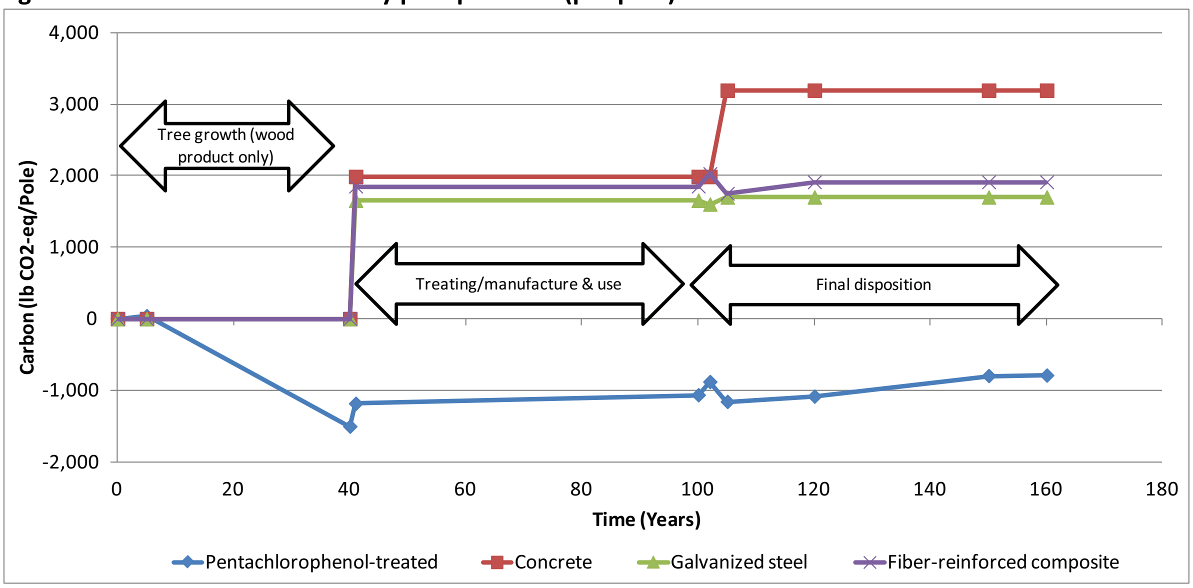
Wood products begin their life cycles using carbon (as carbon dioxide) removed from the atmosphere and atmospheric carbon removal continues as trees grow during their approximate 40 year growth cycle, providing an initial life cycle carbon credit. Approximately half the mass of dry wood fiber is carbon.

Transportation and treating operations are the primary sources of carbon emissions in the manufacture of treated wood products.

Non-wood utility pole products begin their life cycle with the extraction of resources, such as limestone or silica sand or carbon-sequestered resources such as oil and coal, and require energy to convert resources into manufactured products.

Minimal impacts are required for both wood and non-wood products in the service life stage. Following the service life stage, wood poles are recycled for secondary uses, recycled for energy production, or disposed in landfills. Non-wood material poles are recycled, disposed in landfills, or recycled for energy. The carbon balance of each utility pole product through the life cycle stages is shown in Figure 3

Figure 3 Carbon balance for utility pole products (per pole)



Note: Net carbon less than zero is a reduction of greenhouse gas levels in the atmosphere because of the product's manufacture, use and disposal. Net carbon greater than zero is an increase of greenhouse gas levels in the atmosphere.

8. Additional Information

This study is further detailed in a Procedures and Findings Report completed March 10, 2011 and is available upon request from the Treated Wood Council at www.treated-wood.org/contactus.html.

This study has been published in the peer reviewed *Renewable and Sustainable Energy Review* journal and is available at http://dx.doi.org/10.1016/j.rser.2011.01.019.